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THE PAST AND FUTURE OF THE AMERICAN MATHEMATICAL SOCIETY.*

HAVING been requested by the Council to address the Society on retiring from the presidency, it has appeared to me that I must choose between the discussion of the

*Address delivered by the retiring President, before the American Mathematical Society at the annual meeting held December 28, 1894.

position and prospects of some branch of mathematics with which I may be familiar and a more general and discursive review of the present position and future prospects of our Society. I have, after some hesitation, chosen the latter subject. It seems desirable, on the whole, that there should be made at this time some permanent record, however slight, of the steps by which so large and flourishing a society has come together, and of the views concerning its present scope and the hopes concerning its future possibilities which are entertained by those who have hitherto been most immediately concerned in the conduct of its affairs.

The New York Mathematical Society, originating in 1888, was at first not much more than a small mathematical club meeting periodically at Columbia College. The first meeting was called by a circular signed by three young men. The number of those who could be expected to attend these meetings was not great, but all who were able and who were sufficiently interested to do so were invited to join the Society. It was fortunate in securing for its first president Professor Van Amringe, distinguished alike by scientific attainments, official eminence, and administrative ability. The professor of astronomy at Columbia was also active in it from the first. The meetings of the young Society were, as I am informed (for at that time I did not reside in New York),

attended with more than interest, I might say with zeal. The three who called the Society into being may, without invidiousness, be mentioned as having aided materially in the prosecution of its work. One of these of course need not be named to you. He has served from the beginning as Secretary, and again as the leading member of the publication committee. It is no flattery to him to say that the growing energies of the Society must at various stages have become chilled or misdirected, except for his comprehensive intelligence and untiring industry. Another was our former Treasurer, now absent from the country. Still another has been elected by you to-day to the office of Librarian. The meetings were, as the ordinary meetings still are, held at Columbia College, and at that time the majority of the members of the Society were connected with that institution. The President, after two years' service, fearing that the continuance of a representative of that College as presiding officer would tend to hamper its usefulness, proposed the election of a new President not connected with any college. It was in this way and for this reason that you honored me with the post from which I retire to-day. It is not improper for me to add that I am myself an outspoken believer in the doctrine of rotation in office, and that I was only prevented from retiring at an earlier period by urgent representations concerning the presumed welfare of the Society, at a time when all were not yet fully agreed upon the expediency of changes which have since taken place.

The Society was therefore distinguished from all American mathematical clubs or associations by two circumstances: it was formed in and took the name of the largest city of America, and it was distinctly understood to be unconnected with any institution of learning. Suggestions came to be made that its usefulness would be decidedly

increased by the publication of a periodical journal. Consideration of these suggestions by the Council led to the establishment of the Society's *Bulletin*, with the nature and scope of which you are all familiar. It was decided to be inexpedient to publish original investigations, that field being already occupied by successful American periodicals. To meet the expense of the publication, the fees of the members were somewhat increased, and for the same reason, as well as to extend the usefulness of the Society, well-known mathematicians in all parts of the country were invited to become members. That this movement towards enlargement was judicious and timely was proved at once by the rapid growth of the membership, which since the middle of 1891 has included a large proportion of the prominent mathematicians of the United States and Canada. As the Society thus became in reality an association of American mathematicians as a body, the change of name effected this year was only a natural sequence. Finally, the result of the change of name has been that a number of persons, including several of the highest repute, who had not previously joined the New York Mathematical Society, regarding it as a local organization, have connected themselves with the American Mathematical Society; and I need hardly say that, if any one of prominence still holds aloof, from inattention or otherwise, his entrance at any time as a member will be greeted with a hearty welcome.

It is said that when the London Mathematical Society was organized there had been no previous example of a similar organization, and that fears were felt and expressed that its management might naturally drift into the hands of a few having time and energy to give to its affairs, and that there might thus be serious danger of its falling into the control of a clique. The lapse of time has developed the fact that the lead-

ing members of that society have been men of broad views, unusually free from personal prejudice and quick to recognize talent wherever displayed. We may almost conclude from the history of that society that proficiency in the science of mathematics is distinct evidence of a well-balanced mind. It may be doubted whether an equally numerous body of poets or musicians could have held so successfully on its course during half a century. It is of course impossible to predict that the management of our own Society will be equally prudent, energetic and successful during a half century to come. All that can be said at present is that not a trace of personal self-seeking on the one hand or of personal prejudice on the other hand has as yet become visible in our counsels. One single motive has thus far been conspicuous among all who have interested themselves in the Society: a strong belief in its prospective usefulness combined with an earnest desire to further its success.

Thus far I have spoken only of the progress of the organization as such. The organization, however, is merely the framework. It has certain living objects, and even during its period of formation and growth it has been distinctly successful in promoting those objects. I have spoken of objects; the Constitution, however, reminds me that there is but one object: to encourage and maintain an active interest in mathematical science. It is, however, possible to subdivide this very general statement of the aims of the Society. In order to encourage and maintain an interest in mathematical science, we may say, then, (1) that mathematicians must be brought to know more about each other and concerning each other's work; (2) that the number must be increased by the encouragement of the study of the higher mathematics among the young; (3) that information should be disseminated fully and speedily concerning

mathematical publications abroad as well as at home; (4) that, as regards the more important of such publications, competent critics should be induced to write and publish papers descriptive of their contents and indicating their merits or defects; (5) and that every member of the Society should be stimulated to the most successful effort possible in his own line of mathematical labor, whatever it may be. This subdivision is not presented as scientific and exhaustive. Others would doubtless make variations of their own; and it is certain that the separate points I have indicated are not mutually exclusive. I mention these several objects merely as they occur to me for the purposes of this occasion.

That by entering the Society and receiving its monthly *Bulletin* the mathematicians of the United States and Canada have been and are brought to know far more about each other and concerning each other's work than they ever knew before or could possibly have known otherwise is obvious to all. The mere list of members, which conveys to each of us the names, addresses and occupations of all the rest, would alone justify this statement. The *Bulletin*, with its lists and reviews of new books, together with many notes concerning the higher mathematical work of different institutions, has afforded much additional information, and it may be expected that further experience will enable its conductors from time to time to add to its usefulness in this direction.

While the Society is not directly concerned in encouraging the study of the higher mathematics among the young, its indirect influence in that direction has undoubtedly been felt, and must be felt increasingly as time goes on. Years ago, when the present century was much younger, the course of study in our colleges was so arranged as to give a large proportion of the time of the undergraduates to the study of mathematics. Subsequently

the tendency in colleges having uniform courses of study was to cut down the number of hours given to this science, as well as to the classics, and to parcel out the time among the modern languages and various sciences. It is believed that even already the organization, the meetings, and the publications of the Society have, by the effect of numbers in association, perceptibly strengthened the tone of the mathematical departments of many institutions of learning and assisted in enabling them, more or less successfully, to stem the hostile tide of sentiment to which I have just referred. I say 'assisted,' for other agencies, especially the journals, have done great good. That the dissemination of knowledge concerning the gigantic strides lately made and still making in mathematical science must in the future have the same favorable effect to an even greater extent is not to be doubted.

As to the next point in my list of objects, I need hardly mention to you that the Society has succeeded and is succeeding in disseminating information fully and speedily concerning mathematical publications abroad as well as at home. In addition to this general statement, for the proof of which we need only refer to the monthly numbers of the *Bulletin*, I may recall to you that the Society is at this moment engaged in publishing, at its own expense, supplemented by personal subscriptions, one of the largest and most important volumes ever published containing nothing but original investigations; namely, the extensive and very valuable collection of papers—mostly by European authors—prepared for and presented to the Mathematical Congress in 1893, held in connection with the World's Fair at Chicago.

Again, considerable success has been attained in inducing competent critics to write and publish papers descriptive of the contents and indicating the merits or defects of

the more important current mathematical publications in all countries. In this respect it is hoped that the usefulness of the *Bulletin*, already recognized, will be largely augmented as time goes on. You have to-day strengthened the Publication Committee by the addition of a third member of tried capacity. The Committee depends for its critical papers upon the coöperation of other members of the Society, and it is especially pleased to receive voluntary offers of such papers from members who have not yet contributed to the *Bulletin*. It is to this resource as much as to any other that we must look for the enlargement and improvement of the *Bulletin*. The Committee must be aided freely by the presentation of an increasing amount of material from which to choose; and I use this occasion to urge upon each member that he take every opportunity consistent with other engagements to impart to his fellows the historical and critical results of his own reading in any special branch, and particularly in connection with any new and important work recently published in that branch. The well-known saying of Bacon cannot be too constantly before our minds: "I hold every man a debtor to his profession, from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and ornament thereunto."

Finally, and I might say above all, it is the object of the Society that every member should be stimulated to the most successful effort possible in his own branch of mathematical labor, whatever it may be; whether it be in teaching, or writing, or original investigation, or in any combination of these lines of activity. The investigator must also be a writer; the writer may present his own investigations, or comment upon or summarize or write the history of those of others, or elaborate a treatise

or text-book upon some special subject; but whoever may investigate, and whoever may write, it is the lot of almost all of us in one way or another to teach. For this reason it is plain that this Society is, and must always remain, a society of teachers. Any tendency to restrict its usefulness solely to the paths of investigation and publication should, for every reason of prudence and wisdom, be resisted. The management of any organization which does not commend itself to the great majority of those interested must not indeed necessarily end in failure, but must certainly fail of producing the most appropriate, the most useful, and therefore the best results. While, however, expressing this general opinion, I would by no means be understood to disparage the work of the writers and investigators. Not every teacher, however successful, feels impelled to write for publication, and not every writer has time and facilities for original investigation; yet we all of us take pride in such work when done by others, and we all of us, as members of the Society, feel that it would fail of its highest objects if it did not encourage in every way the production of good papers and books and, above all, the prosecution of original discovery.

In encouraging the writing of books, as distinguished from the prosecution of original research, the Society can do little except indirectly, by increasing the possible demand for such works. The need of what we may call advanced text-books giving, as far as possible, summaries of existing knowledge in the several higher branches, has long been felt, and of late years has to some extent been supplied. Some of these fields, however, are still open; and as time goes on, fresh books, to take the place of those now fresh, will still be wanted; for our science is in all points, even those sometimes regarded as most stationary, in a condition of advancing evolution. It is, if you please,

the same old oak, but what formerly were twigs are now sturdy limbs, and what now are tiny stems may soon be recognized as vitally important branches. As to the making of thorough and systematic books on mathematical subjects, it has before now been remarked that the task is really more difficult, for some at least, than that of working up original papers. Some of the reasons for this were clearly stated by Mr. Glaisher in his presidential address in 1886 before the London Mathematical Society. I recall the case of a friend who at one time began the preparation of a summary of knowledge in a special field; but he had not gone far before he found such temptations in the way of unifying theories or bridging over gaps that the result was the production of two or three contributions to the journals and the abandonment of the book. We must, I think, accord unusual honor to those who apply themselves successfully to the task, more arduous every year as the mass of original work rolls up, of summarizing and condensing into clear bodies of doctrine all existing important discoveries in special fields of mathematical labor, certainly without hope of pecuniary reward and usually without prospect of any wide circle of readers.

As yet the Society has done little towards the encouragement of writing and investigation. The existing well-known and successful journals maintained, whether by a great university, by scientific societies of a general character, or by the generous efforts of individuals, have afforded opportunities for the publication of extensive papers with which the Society's *Bulletin* is not intended to compete. For much the same reason those of its members who have been personally solicited to give their aid have been appealed to for contributions to the *Bulletin* rather than for original papers to be read and discussed at the meetings. It is to be hoped that, as time goes on, the

members of the Society will become more and more accustomed to present their original papers for reading at the meeting, before publication. It may perhaps also be expected that a closer connection may be developed between the reading and the publication of such papers, whereby, on the one hand, perhaps, editors of journals may, as members of the Council or otherwise, have some preliminary oversight of the acceptance of papers for reading, and whereby, on the other hand, the acceptance of a paper for reading shall insure its speedy publication.

While the Society can thus do little directly to encourage the writing of important treatises, it can and should, without doubt, do much to stimulate original research. Original discovery has always been recognized as the quickest and surest road to distinction. A permanently valuable paper read and discussed at a meeting of the Society becomes an immediate object of interest to those who attend; the subsequent record of the reading in the *Bulletin*, supplemented, perhaps, by a brief abstract, excites a still wider interest among the membership at large; and in this way many of the readers are prepared to welcome the publication of the paper when it appears. There are—apart from the institution of medals or prizes, which would be within the Society's province—many other ways in which, directly or indirectly, the influence of the Society may be felt in turning the attention of individuals to the importance of original work. And as some slight contribution towards this desirable end, I shall close this address with a few remarks and suggestions intended more particularly to reach those members of the Society whose attention is turning in this direction, but who have not as yet produced original papers. If in doing so I happen to give good advice, particularly as regards style, of which I have not always succeeded in

following myself, I trust I may be favored with the same kindly personal consideration as is customarily accorded to an emaciated physician or to a stammering professor of rhetoric. Yet as to the style in which a mathematical paper should be written, as distinguished from good English style in general, there is not really very much to be said. Such papers should contain good English, and enough of it. Obscurity, above all things, should be avoided. The printer should not be annoyed unnecessarily by complicated fractions and other things difficult to print. Phrases and symbols familiar to the writer, but not necessarily familiar to his readers, should not be introduced without explanation. Such phrases and symbols can always be explained by taking the time and trouble; and though the paper be made somewhat longer, it becomes far more satisfactory. It is of course possible, especially if one has not much to say, to err in the opposite direction by diffuseness and verbosity. The golden mean lies in the distinct explaining of every symbol, of every phrase not universally understood, and of every step in the discussion in language otherwise extremely concise.

It would doubtless excite a smile were it known that any young man was for the first time saying to himself: "Go to! let me make a discovery." Yet that is what each one implicitly does say to himself who makes any discovery. It is hard to imagine how any new point could occur fortuitously to an investigator not engaged in investigating. No one can tell until he tries whether or not he is fitted for that sort of work. No one can be sure, even though failure come to him after failure, that he shall not later meet with success. One sort of failure, indeed, should convey the most flattering encouragement. It is when a supposed discovery is made, which proves on further in-

quiry to have been made long before by some one else. The immediate effect is disheartening; and yet the occurrence has established the existence of the power of discovery. When once anything, no matter what and no matter how old, is discovered afresh and originally, the beginner has only himself to blame for any subsequent want of success. It may, in fact, be doubted whether every earnest mathematician who takes pleasure in his work has not in him, to some extent at least, the capacity for discovery. Indeed, any fresh solution of an interesting problem, any new proof of an old proposition, is in itself a piece of original work. Undoubtedly some are born with greater capacity than others; yet no one can tell, without trying, the limits of his own capacity in this direction; and it is probably true in this, as in other lines of effort, that genius consists in an infinite capacity for taking pains.

He who for the first time makes an attempt towards original mathematical research must do so either in pure or in applied mathematics. By far the greater number of papers relate to the former class of investigations; and yet it would seem that greater opportunities for attaining important results lie in the latter direction. We all of us know, in a general way, that many important improvements in pure mathematics are the direct result of efforts connected with practical applications. Our knowledge of the laws of physics is constantly undergoing development. Just now, perhaps, the most important improvements are those connected with the laws of electricity, in which some of the members of this Society have taken a prominent part. Mr. Walker, in his presidential address of 1890 before the London Society, brought forward numerous instances illustrating the enormous influence of applied mathematics upon the progress of the pure science. The numerous illustrations which

he adduced should be consulted by every one interested in the applications, and should encourage him to active effort in extending the domain of applied mathematics, and thereby almost necessarily adding to existing knowledge in the region of pure mathematics.

For some reason which no one has undertaken to explain, but probably connected with the much wider dissemination of elementary instruction in pure mathematics as compared with applied, by far the greater number of investigations thus far have related to pure mathematics; and it may be presumed that for some time to come this disproportion will continue. In other words, our young mathematician who says to himself that he will make a discovery is most likely to confine his efforts to that in which he has been most thoroughly instructed and with which he is therefore the most familiar—the pure science. How, then, is he to set about it? One way, and a most satisfactory one, would be to take part in some such *seminar* as that at Göttingen, described some time since in our *Bulletin*. Another quite similar method is to begin by assisting some active investigator and carrying out his suggestions faithfully. The impulse given to a number of our best men in this way by Professor Sylvester when he was in this country is well-known to us all. On the other hand, any attempt at collaboration between two equals would seem almost certainly predestined to failure. Though exceptions are well known, it is really rare to find any fresh and important development in a paper worked up by two friends of equal skill, and still rarer to find a succession of papers by the same pair of authors. Good practice, however, can be had in correspondence between two friends on some fresh subject, each sharpening the mind of the other, provided the correspondence be carried on as a matter of growing interest between the two, rather

than for the purpose of producing a joint publication. As a rule, however, the young discoverer works alone, and he will most likely find, before he gets to the publishing stage, that his first discoveries have been made earlier by others. He must choose his subject according to his own taste. Usually he will be led most easily to some fresh result, if he reads and digests with keen interest the latest publications of others upon some growing subject. He may, perhaps, perceive that one of these papers has not exhausted all the possibilities; or he may, by an alteration in the point of view, find himself enabled to obtain the same result by a much shorter and more satisfactory process. He must not fear that he is giving his mind to a subject too trivial. No matter how slight the addition which he makes to the sum of knowledge, it is yet an addition, and unless it is superseded by the doing of the same thing by some one else in a better manner, it is a permanent contribution to science. Some are helped greatly, at times, by working first on some numerical illustration of the problem in hand; others, again, by a preliminary geometrical representation; and the first path to any discovery is not usually the best. It is sometimes supposed that the mass of original work done in so many countries and published in so many languages makes it likely that any ordinary piece of work will be overlooked in the great mass. Nevertheless, *littera scripta manet*; and what may now seem an unimportant addition to an unimportant branch may probably one day, when that branch is no longer unimportant, and when its special history comes to be itself a topic of discussion, receive its due recognition. Meantime, every little helps. The most trifling addition to the actual sum of knowledge will be at least useful as a step to aid the next investigator; but whether important or unimportant, whether appre-

ciative recognition comes or not, whether others are helped or no one takes notice, there is a degree of personal pleasure in the mere fact of origination which is the just and certain reward of every piece of successful investigation.

EMORY MCCLINTOCK.

NEW YORK.

THE ORIGIN OF OUR VERNAL FLORA.

THOSE who have collected flowering plants for many years, without a doubt have been impressed with the wonderful regularity and precision displayed in the successive flowering of different species, even genera of plants. The character of the vernal flora in the northern United States* depends on the seasonal development of plants belonging to different natural orders. Each plant, even orders of plants, have definite times of appearance, when their flowers open, fertilization takes place, and seeds are distributed. At times, a lull or break in the continuity of this floral procession takes place just before the true summer plants appear. Such a break seems to occur in the neighborhood of Philadelphia between the twenty-fifth day of May and the tenth or fifteenth day of June, when the first true summer plants appear. Curiously enough, this period corresponds with the time of the ice saints in the United States, when there is a possibility of frost over a large portion of our con-

* The advent of spring may properly be considered as taking place at the approach of an isotherm one degree higher than 42.8° F., the general limit of protoplasmic activity. There is no temperature in the extreme South, in the vicinity of the Gulf, below 43.8° on the average, and there is therefore no advent of spring; no real beginning of vegetation and re-clothing of trees with leaves. On February 1st, the isotherm in question is found crossing the United States from the vicinity of Cape Hatteras on the east to the north of El Paso, then northward to the Pacific near San Francisco Bay. The phenomena of winter are to be found north of that line. See *Harper's Monthly Magazine*, May, 1894, page 874, article by Mark W. Harrington.

tinental area.* A floral calendar might be constructed with the dates of germination, seed discharge and death of annual plants, and it would be found that a plant year after year departs very little in the time of its appearance from the dates put down in this vegetal almanac. Take a common agricultural plant by way of illustration. The planting season for Indian corn is from the 1st to the 10th of May in favorable weather. One hundred and ten days from date of sprouting to date of ripening or security from frost is about the average season. In many cases in the corn belt, Nebraska for instance, the farmers are quite sure of at least one hundred and twenty days. All this goes to prove that each plant has a peculiarity of its own with regard to temperature and environment; that the sum of the mean daily temperatures from the time of sprouting until the time of seed discharge is pretty nearly a constant one, and that if a plant be watched for years in succession it will be found that this thermometric sum oscillates little either way from the plant's normal. It is desirable that our native plants should be investigated as to temperature conditions, for some rule must determine the appearance of plants, the time of flowering and the time of suspended growth. It is no haphazard process, but depends on fixed laws of growth and development. The daily appearance of new plants depends considerably more on the habits of their ancestors than on the controlling influence of present meteorological conditions.

Our forest trees show some very interesting peculiarities in their early spring development, which is apparently caused by their past conditions of growth and development. Heredity seems to play a very important role in their vegetative habits. The facts condensed in the accompanying table will help to elucidate this statement:

* See *Harper's Magazine*, May, 1894.

Plants wind- fertilized, flowering from March to June.	Cretaceous or Chalk Period.	{ Quercus (oaks), Fagus (beeches), Salix (willows), Platanus (plane-trees), Sassafras, Laurus, Magnolia, Liriodendron, (tulip-trees), Myrica (wax myrtles), Betula (birches), Liquidambar (gum-trees), Juglans (walnuts), Acer (maples).
	Post-Cretaceous.	{ Cornus (dog-wood), Nyssa (sour-gums), Fraxinus (ashes).
	Eocene.	{ Ulmus (elms), planera, Celtis, Carya (hickory), Vaccinium (blue-berries).
	Miocene.	{ Alnus (alders), Carpinus (horn-beam), Negundo.

Italicized genera insect-fertilized.

It will be seen from this table that the more important genera of trees flower in the early spring. The cause for this is to be found in the past history of the plants, for if we arrange them, as in the table, as to their appearance in geological time, we discover that nearly all of them appeared before or during the Miocene (middle Tertiary or Mammalian Age) Epoch, when the northern hemisphere was many degrees warmer than at present, and when a mild climate extended far into the arctic regions. It is impossible to ignore the force of the testimony as to the continuous warm climate of the north temperate and polar zones throughout Tertiary (Mammalian) Times. We have in the lower Cretaceous (Chalk) Period an almost tropical climate down to the upper Eocene (Lower Tertiary), when it remains warm temperate, for instance, in central Europe and cold temperate within the polar area. It then gradually cools down and merges through the Pliocene (Upper Mammalian) into the Glacial Epoch. That being the case, it is highly probable that the season of growth of our forest trees during the Miocene Period was uninterrupted, and that flowers followed rapid vegetation, as night follows day. The Glacial Period succeeded with its cold acting as a

disturbing influence, cutting off the growth of the trees sharply just before the flowers opened. The stately monarchs of the Pliocene forests began to change their habit and adapt themselves to the new meteorological condition, the ever increasing cold. The unopened flowers were enveloped by the yet undeveloped leaves, which became harder and firmer, forming membranaceous and resinous covered bud scales, as a protection against the ice and cold. Flowers thus protected remained dormant during the long glacial winter, and on the return of the next growing season opened their flowers for wind fertilization. This habit of early flowering became impressed so strongly on the plants that it became hereditarily fixed. Trees of abnormal habit frequently show atavism, flowering in the late autumn, if exceptionally warm. This apparently indicates that the cold cut into two periods the normal process of plant growth. The division, thus, of the period of growth into two unequal halves by the glacial cold explains why our forest trees have varied little during the process of time from a wind pollinated (anemophilous) state, because their floral organs are developed in the spring before the appearance of the most highly specialized flower visiting insects. Two causes have operated to keep our trees permanently in an anemophilous condition, first, the separation of the vegetative and reproductive stages by the cold of the Glacial Epoch, and their early spring flowering; and secondly, the association of trees together into forests, flower visiting insects loving essentially open glades, or areas devoid of timber.

More difficulty is experienced in explaining the appearance of the herbaceous vernal flora. In order to arrive at a clear understanding of the problem, a few statistics are necessary.

The following table compiled from a variety of sources arranged for convenience of presentation according to the system of

A. L. Jussieu (now little used) will be of use as approximately showing the statistical systematic distribution of our spring plants.

		Darrach. ¹	Darlington. ²	Gray. ³	Rothrock. ⁴	Burk. ⁵
Dicotyledones	Polypetalæ {	Stamina epigyna	6	—	—	3
		“ hypogyna	91 61 86 75 22	—	—	—
		“ perigyna	6 18 17 30 16	—	—	—
	Monopetalæ {	Corolla hypogyna	13 12	9 11	17	—
		“ perigyna	—	—	—	—
	Apetalæ.	epigyna	8 5 9 13 9	—	—	—
			6 15 13	—	—	6
Monocotyledones.			26 15 12	—	—	21

A predominant number of the plants, tabulated in the foregoing table, fall into eight natural orders: Ranunculaceæ (buttercup family), Cruciferae (cress family) Violaceæ (violet family), Caryophyllaceæ (pink family), Rosaceæ (rose family), Saxifragaceæ, Ericaceæ (heath family), Compositæ (sunflower family). The plants belonging to these eight natural orders form the major and characteristic part of our spring flora, and with the exception of the Ericaceæ and Compositæ (few in number) are all polypetalous (many petals, distinct), and monocotyledons hypogynous (stamens and parts below the ovary) in its make-up. The more complex and irregular flowered families appear later in the year. Now this order of flowering corresponds curiously with the order of evolution of the flowering plants, which was suppositiously as follows:

A. Monocotyledons. Wind Fertilized. Grasses, Sedges.

B. Dicotyledons.

1. Wind Fertilized. Trees.

2. True Insect Fertilized.

(a) Polypetalæ. (Petals distinct, 4 or 5.)

(b) Gamopetalæ. (Petals united.)

This comparison leads us to infer the ab-

¹ Darrach, Proc. Acad. Nat. Sci., Phila., 1860, 145;

² Darlington, Flora Cestricea; ³ Gray Manual; ⁴ Rothrock, Flora of Alaska; ⁵ Burk, Flora of Greenland, Proc. Acad. Nat. Sci., Phila., 1894.

sence of true flowers until late geologic times, for it is only by the visits of insects and their irritating action on vegetal protoplasm that the most irregular flowers have been slowly evolved, for there is a broad parallelism between the more differentiated types of the vegetal kingdom and the appearance of the various orders of insects, which was :

GEOLOGICAL SUCCESSION OF INSECTS.

Devonian, Orthoptera (ear-wigs, grasshoppers), Neuroptera (ant-lions).

Carboniferous, Coleoptera (beetles).

Cretaceous Olite, Hymenoptera (bees), Hemiptera (lice), Diptera (flies).

Tertiary, Lepidoptera (butterflies).

We know from the close association of insects and flowers that the insects were modified by their visits to flowers, and conversely that flowers have been changed to suit the visits of insects, and it is therefore not improbable that our most highly specialized flowers, and most irregular ones, appeared and were modified by the Lepidoptera in the late Tertiary time; for moths and butterflies are most highly specialized to insure cross fertilization, or allogamy. This variation in flowering plants must have been most strong at the close of the Miocene period, and after the retreat of the glaciers still more rapid than before, for it is probable that the intense struggle which took place by the migration and intermixture of forms of different kinds, occasioned by the change of environmental conditions, was a powerful factor in causing the striking variety of flowers and insects. The 'responsive power' of the protoplasm of the plants, acting in concert with the external impulses received from the environment, must have been strong after the disappearance of the glaciers, on account of the re-occupation of a barren glacial country by northward moving plants, whose protoplasm had become responsively mobile during the long continued struggle in the south.

It is not at all improbable that the poly-

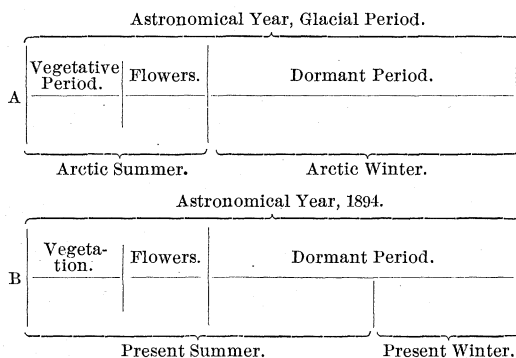
petalous groups of plants were northern ones during the Miocene period, and that their flowering period depends on this past geographical position. Those plants which lived far north during late Miocene and Pliocene times were least modified, for it is likely that moths and butterflies were then few in number, and the time was not sufficiently long for change to take place before the glacial ice sheet moved southward, mixing the northern and southern types, and introducing a struggle which was to last until the ice disappeared by the temperate heat. Many tropical plants remained associated with the northern forms crowded southward by the glaciers, notwithstanding that a great number perished under the more rigorous conditions of a colder climate. When the glaciers retreated, the predominant polypetalæ adapted to a cold climate did one of three things: 1. They retreated northward. 2. They retreated up the high mountains. 3. They took almost exclusive possession in their growth of the spring months, for the temperature conditions are such as to suit well their hereditarily impressed preference for the cold.

These plants flower and mature their seeds quickly before the summer is well advanced, which mark them as physiologically adapted to the influences of the short glacial summer, alternating with the long glacial winter. This rapid growth production of flowers and seed in a short space of time is possible from the quantity of nutritive material stored up in the plant. The beet, turnip, parsnip and carrot are familiar examples of biennials with the reserve substance packed in the roots; the houseleek, lily and onion with the bases of the leaves enlarged and thickened to contain the stores of starch, sugar and proteids. Even under these favorable conditions, when the plant would be in a condition to grow most vigorously, every externally perceptible vital motion nevertheless ceases, and it is only after a dormant

period of some months that growth commences anew, and this frequently under circumstances which appear far less favorable—especially at a conspicuously lower temperature. “This periodic alternation of vegetative activity and rest is in general so regulated that, for a given species of plant, both occur at definite times of the year, leading to the inference that the periodicity only depends upon the alternation of the seasons, and therefore chiefly upon that of temperature and moisture.” A few well-known examples are selected for illustration. “The leaf-shoot and flowers contained in the bulb of the Crown Imperial commence to grow vigorously in the spring-time with us, even at the beginning or middle of March, when the soil in which the bulb has passed the winter possesses a temperature of 6–10° C.; the leaf-shoots protrude forcibly from the cold earth to grow vigorously in the but slightly warmer air. There would be but little to surprise us in this, if we did not at the same time notice the fact that a new leaf-shoot is already formed in embryo in the subterranean bulb in April and May; this shoot, however, does not grow to any extent in the warm soil during the summer and autumn. On the contrary, this favorable period of vegetation passes by, until at the end of the winter an inconsiderable rise of temperature above the freezing point suffices to induce vigorous growth; and as is well known, the same is the case with most bulbous and tuberous plants, as the meadow saffron, potato and kitchen onion.”

“I have many times attempted to induce the tubers and bulbs ripened in autumn to put forth their germinal shoots during November, December and January, by laying them in moist, warm loose soil; but as in the case of the potato, as well as in that of the kitchen onion, no trace of germination appeared. If, on the other hand, the attempt is repeated in February, or still better in March, the germinal buds begin to grow

vigorously even in a few days. It is evident that some internal change must have taken place in the tubers and bulbs during the winter months, when it is impossible to bring them into activity from their state of rest.” Our spring plants in this agree physiologically with their arctic congeners. The period of rest described above in such early spring plants, as the winter aconite, crocus, Erythronium, etc., has in my opinion been due to the influence of the glacial cold hereditarily impressed on these plants in connection with the chemical changes which go on. The following diagrams will illustrate my meaning. Diagram B shows that the period of vegetative activity of our spring plants corresponds with an arctic or a glacial summer, while the dormant period corresponds with an arctic winter, although our present summer has encroached on the former glacial winter.



It was necessary for this rapid growth that the food material should be prepared beforehand, because the arctic or glacial summer is an exceedingly short one. Mr. Henry Seebohm,* in his presidential address before the Geographical Section of the British Association, gave a graphic description of the succession of the seasons in high arctic latitudes. A few sentences are worth quoting in this connection. He said that the stealthy approach of winter on the confines of the polar basin is in strong contrast to the

*See *Popular Science Monthly*, XLV., 138, May, 1894.

catastrophe which accompanies the sudden onrush of summer. "One by one the flowers fade and go to seed, if they have been fortunate enough to attract a bee or other suitable pollen-bearing visitor. The arrival of summer happens so late that the inexperienced traveler may be excused for sometimes doubting whether it really is coming at all. When continuous night has become continuous day without any perceptible approach to spring, an Alpine traveler naturally asks whether he has not reached the limit of perpetual snow. During May there were a few signs of the possibility of some mitigation of the rigors of winter, but these were followed by frost. At last, when the final victory of summer looked hopeless, a change took place; the wind turned to the south, the sun retired behind the clouds, mists obscured the landscape, and the snow melted 'like butter upon hot toast,' and we were in the midst of a blazing hot summer picking flowers of a hundred different kinds and feasting upon wild ducks' eggs of various species."

The polypetalous families which blossom early in the season, although old geologically speaking, have not been greatly modified since Pliocene times, because their flowers open in the spring before the Lepidoptera hatch out from their cocoons. It is obvious that every species of flower can only be visited and fertilized by those insects which occur at the time when the plant is in flower and in stations where it grows. The insect visitors of a plant are therefore limited by the season and by the time of day when it flowers, by its geographical distribution and by the nature of its habitat. The high northern polypetalæ have remained therefore regular while those plants growing in the southland have become highly irregular by the visits of numerous highly organized insects in great number near the equatorial zone. We must be cautious, however, in generalizing

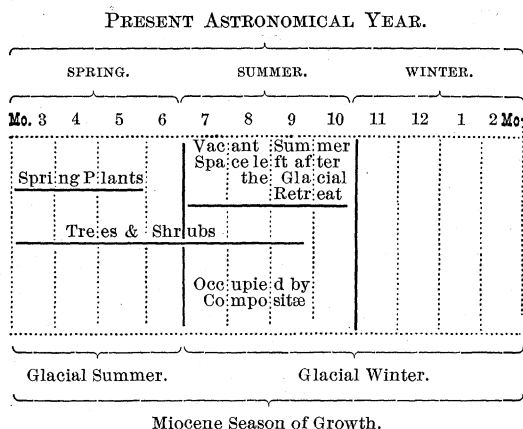
too broadly, for we can only call those parts perfect which fulfill their purpose in the life of the plant essentially well; that is to say, which under existing conditions insure the sexual reproduction of the species with particular success.

The Compositæ (sun-flower family), the highest expression of evolution amongst Dicotyledons, appeared latest in geological succession, for no undoubted form of them (Synantheræ) has been found farther back than the middle Miocene. Müller says: * "The numerical preponderance which this family has attained in species and genera (1000), and the extreme abundance of many of the species, are due to the concurrence of several characters, most of which singly, or in some degree combined, we have become acquainted with in other families, but never in such happy combination as in the Compositæ. The following points deserve special mention: (1) the close association of many flowers; (2) the accessibility of the honey as well as the plentiful secretion and security from rain; (3) the possession of a pollen mechanism, which renders cross fertilization certain in the event of insect visitors." It is a masterful order of plants most commonly met with in the late summer and autumn, flowering profusely until the heavy frosts of early winter, when they cast their seeds abundantly. An enumeration of the Compositæ growing in the vicinage of Philadelphia shows that the plants are essentially late summer growers.

FLOWERING TO FRUIT RIPENING.	NUMBER OF PLANTS.
April-May,	2
May-June,	4
June-July,	6
June-August,	4
July-August,	8
July-September,	15
August-September,	32
August-October,	35
September-October,	15
	121

* Müller, *The Fertilization of Flowers*.

These are the latest group of plants to appear geologically, they grow and flower in the warm season added to the short arctic summer by the retreat of the glacial winter. The following diagram will indicate more clearly what is meant, and will show why it is that the Compositæ of the north temperate zone are the characteristic herbaceous vegetation of the late summer and autumn months.



The land area left bare by the retreat of the glaciers was one of low tension, although by the increase in the length of the summer (some three months) it had a climate in every way suited for the growth of plants. The country to the south was one of very high pressure tension, which must be relieved. The great strain was removed partially by the movement of plants to the northward. "Of all the plants which went south before the first invasion of the glacial ice sheet, none showed greater capacity for variation and improvement than the ancestral forms of the modern dominant family of Compositæ." Such plants in having seeds adapted to fly before the prevalent north winds had reached a low latitude, where great change of form took place owing to the intense struggle for existence. The composite plants were assisted northward by the same structural means as carried them south. Modified considerably

into new forms by their migrations and life in the south, they retained their fondness for a warm climate. By the extension of the arctic summer, some three months, they had an opportunity for extensive migration over the country formerly ice bound.

It is thus from the high and low pressures, caused alternately by the glacial epoch, that the distribution of our flora in time has been accomplished.

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ON CERTAIN HABITS AND INSTINCTS OF SOCIAL INSECTS.

If the mere inductive evidence for the Lamarckian theory of the hereditary transmission of acquired characters be strong anywhere, it is assuredly in the region of nervous and mental phenomena. Romanes, whose reserve on the inheritance of acquired characters of a physical nature is everywhere manifest, admits that many instincts are due to the 'lapsing of intelligence.'* "Just as in the lifetime of the individual, adjustive actions which were originally intelligent may by frequent repetitions become automatic, so in the lifetime of the species actions originally intelligent may, by frequent repetitions and heredity, so write their effects on the nervous system that the latter is prepared even before individual experience to perform adjustive actions mechanically which in previous generations were performed intelligently."

Even Weismann, with all his wealth of imagination and capacity for elaboration of details, has nowhere attempted to trace out the mechanism for the evolution of instinct on the line of his 'germ plasm theory,' nor applied to it the manifold combinations of 'biophors' and 'determinants,' 'ids' and 'idaunts' which he assumes as the machinery of inheritance. So far the only

* *Mental Evolution in Animals*, p. 178.

key to many instincts is found in the conception that they are inherited habits, themselves the originally conscious reactions of the individual to its surroundings ; and this conception has never been seriously attacked from the front in open field. Yet Darwin and all his followers have regarded the habits and instincts of social insects as mainly if not wholly evolved by casual variations and natural selection. For the origin of the instincts and habits of these creatures cannot obviously be explained on Lamarck's principle, since they are for the most part evinced by the workers and soldiers, who are neuters ; and such, of course, cannot transmit their instincts by blood to their followers, who are only collaterals and outside the direct line. Here and there, indeed, these neuters may lay eggs, unfertilized but not infertile, since in the bees they produce drones and in some ants also males ; but we have no evidence that this occurrence is frequent or regular enough really to influence the race. However, there are two matters, the so-called instincts of neuters generally, and those of slave-makers in particular, that may be dealt with from a point of view which will show that an explanation is available that makes no excessive demand on Lamarckians.

It is a truism to say that one of the most potent factors in education is the imitation of one's peers. As a teacher of experience, I know well how the presence of a few bright and handy students eases my annual task of breaking in a class of book-taught lads to a study requiring handiwork and observation. The nearer akin the model, the more powerful is his example. Thus, the trained elephant is an almost necessary aid to the tamer of wild elephants ; no bird-organ can do as well as a good songster ; and if we wish to train a daw, magpie or starling to speak, its best teacher is a loquacious parrot.

Animals may readily thus acquire *habits*

which, if we did not know their origin, we might well mistake for *instincts*. Thus a dog reared by a she-cat has acquired the habit of sitting up on his tail, licking his paws and washing his face—watching a mouse-hole for hours together ; 'and had in short all the ways and manners and disposition of his wet nurse.'* So that in considering the behavior of any species we have to be cautious and bear ever in mind that manifestations which at first sight seem unequivocal instinct may be really habit, and habit only.

Now every neuter insect is born from the pupa (as it was born from the egg) into a community of busy workers of its own kind, practising the art that she† will have to practise in turn. If then her mental powers and emotional development are up to the average of the race there can be no difficulty in her qualifying for the place she will take in the nest. Again we must remember that this neuter insect hatches from the egg into a helpless larva, to be fed and tended with most devoted care by the adult sister workers until it passes into the chrysalis or pupa stage, where it sleeps out the transformations that make it an adult. We know well that neuter insects show every sign of varied emotion ; everyone can tell the difference of demeanor between the busy bee and the angry one ; and observers have shown us ample evidence of many other emotions. If then memory of the earlier larval state survives the pupa trance‡ our

*See Romanes, op. cit., p. 226.

† The so-called neuter is always an imperfect female.

‡ Lubbock has shown that ants will tend any young whatever of their own species even if born in other nests ; but none the less they do reject them as strangers after they have passed through pupadom into the adult state, while they welcome back the offspring of their own nest that have been fostered by strangers. The converse experiments have not been tried, to ascertain whether the new-born adults that have been nursed outside their own nest show any memory of or preference for their own folk or their fosterers respectively. (See Lubbock, 'Ants, Bees and Wasps.')

newly emerged neuter should revive with the liveliest gratitude and almost filial affection for its mates, who have tended it as devotedly as elder sisters in charge of a family do even among ourselves.

The only possible objections to this view are, first, that the insects have not intelligence enough for imitation, and secondly, that teaching presupposes communication between the teacher and the taught, which we have no right to assume. But these objections fall as baseless when we observe for ourselves, or trace with a Huber, a Forel, a Lubbock, or a Bate the unmistakable intelligence and the unequivocal signs of communication to be found among these animals.

We may still assign to natural selection a certain part, much more limited than has hitherto been supposed. It conserves the general intelligence of the race at a high pitch, by constantly weeding families prolific of foolish virgins; and it checks all excessive development of individuality by destroying families with an undue proportion of those geniuses who aim at striking out new paths for themselves instead of devotedly working at their settled coöperative tasks. But the singular mixture of ability and routine displayed by ants and bees is just what we should expect if their arts were largely attained by the influence of strong tradition. Our lawyers till quite recently showed the severe limitations imposed by tradition on intelligence. And this is my case for regarding the ways of neuter insects as habits and practices, not instincts. Many ants make slaves; they raid the nest of other species, killing the adults and bringing home the helpless young. These are nursed by workers of the same slave race that were once themselves brought in the immature state to the nest. Some of these slave makers can neither clean themselves nor feed themselves; everything has to be done for them

by their slaves, save the work of war and capture.

Lubbock writes: "They have lost the greater part of their instincts; their art, that is, the power of building; their domestic habits, for they show no care for their own young, all this being done by the slaves; their industry—they take no part in providing the daily supplies if the colony changes the situation of its nest, the masters are all carried by the slaves on their backs to the new one; nay, they have even lost the habit of feeding . . . However small the prison, however large the quantity of food, these stupid creatures will starve in the midst of plenty rather than feed themselves."

The origin of this character is not far to seek; the fertile insects, *i. e.*, the males and perfect females of social insects, contribute little or nothing to the work of their nest save their offspring*; hence in the parents of each generation there is a constant fostering of selfishness and dependence to be transmitted to their offspring.

The female or queen termite (or White ant), indeed, is guarded from all exertion and tended in a way to satisfy the indolence of the most languid creole fine lady; the only drawbacks of her position being lack of amusements and of lovers on the one hand and an excessive fertility on the other. Where all or many of the neuters are workers, indolence and selfishness are checked and natural selection constantly eliminates those families whose altruism is insufficient for a social life. But if once circumstances arrive in which slaves are present to do the duties, it is easy to see how all the traditions of work or self help—save in war—can die out and be utterly lost, bravery, pugnacity and honorable coöperation being the sole virtues to survive. It seems at first sight strange

*The amount done is perhaps greatest among Wasps and Humble Bees, least among Termites.

that the slave holders have lost the power of feeding themselves; but this is not unexampled in human affairs. Surely many a fine lady might starve outright in a place with no provender but live fowls and unthreshed wheat and water, no utensils but dry sticks and a few stones. Yet we know that savages of far lower wit could kill and pluck the fowls and get fire, spit and roast them, crush the wheat between the stones and make a damper cook it in the embers. This is a case of the loss of the power of self help by peculiar education, and if we admit this explanation for the fine lady we have no right to reject it for the slave holding ant.

I am aware that I have not dealt exhaustively with the whole question of social insects. There are lots of cruxes in their manners and customs, and especially in the manifold forms that occur in one and the same species. Why, for instance, worse food and a narrower cell should make a fertilized bee's egg become a sterile worker instead of a queen, no one knows; and the problems presented among ants are far more difficult and complicated. But it is as well to take stock frequently of our speculations, and to place our certain realized assets to the credit side, even though we have to keep most of our accounts open indefinitely.

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THE PROPER SCIENTIFIC NAME FOR BREWER'S MOLE.

THERE are three species of moles in the Eastern States, the Star-nosed mole, *Condylura cristata*, the common or Shrew mole, *Scalops aquaticus*, and a third less familiar species known as Brewer's mole, or the Hairy-tailed mole. It is to this last species that my remarks relate. It was described by Bachman in 1842 in the *Boston Journal of Natural History* (vol. 4, page 32) under the name of *Scalops breweri*, and was cited under that designation until 1879, when Dr. Coues

proposed to change the specific name to *americanus*. This proposition was based on the fact that in Harlan's *Fauna Americana*, published in 1825, the name '*Talpa americana*, black mole, Bartram's manuscript notes,' occurs in synonymy at the head of a description which Dr. Coues thought might be in part, at least, applicable to the species under consideration.

I find, however, that this is a literal translation of Desmarest's description of the European mole, *Talpa europæa*, with no additions whatever, and no other alteration than the omission of a word or sentence here and there. It is evident, therefore, that Harlan included nothing from Bartram's manuscript, whatever it may have contained, and that the name *Talpa americana* has no validity.

It will be necessary to return to the specific name *breweri*. I recently separated Brewer's mole as the representative of a distinct genus, which I called *Parascalops*. If this distinction be accepted, the proper name of the species will be *Parascalops breweri* (Bachman).

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THE AMERICAN FOLK-LORE SOCIETY.

THE annual meeting of the Society was held at the Columbian University, Washington, December 27th and 28th. Owing to a death in his family, the President, Dr. Alcee Fortier, of Louisiana, was prevented from attending.

The Secretary, Mr. W. W. Newell, submitted a report in which he detailed the publications of the Society for the year. These included two volumes of 'Folk Tales of Angola,' prepared by Heli Chatelain, late United States commercial agent at Loanda, West Africa, and papers by various well-known authors as follows: 'Notes on the folk-lore of the mountain whites of the Alleghanies,' J. Hampton Porter; 'Three

epitaphs of the seventeenth century,' Sarah A. P. Andrews; 'Popular medicine, customs and superstitions of the Rio Grande,' Capt. John G. Bourke; 'Plantation courtship,' Frank D. Banks; 'Retrospect of the folk-lore of the Columbian Exposition,' Stewart Culin; 'Eskimo tales and songs,' Franz Boaz; 'Popular American Plant Names,' Fannie D. Bergen.

A large number of papers were read before the Society and discussed by the members present. The first was by Dr. Washington Matthews, entitled 'A Navaho Myth,' which related in detail one of the sacred legends of the tribe.

Capt. R. R. Moten then read a paper on 'Negro folk-songs,' in which he spoke of natural musical tendencies of the colored race and reviewed a number of the old songs of the South before the war. Negro music, he said, might be divided into three kinds, that rendered while working, a different kind for idle hours, and a third and more dignified sort used for worship. Capt. Moten said the general public had but little idea of the old negro music, and that many of the so-called negro songs rendered by white men in minstrel performances were abortions. There were some old familiar melodies, however, which were true to nature, and full of inspiration.

A quartet of colored men was present, and sang a number of negro songs illustrating the points brought out by Capt. Moten.

Several speakers dwelt upon the important question of the diffusion of folk-tales and the explanation of striking similarities found in localities widely apart. Mr. W. W. Newell was inclined to explain such by theories of transmission; while Major J. W. Powell and Dr. D. G. Brinton, both of whom had papers on closely related topics, leaned toward the 'anthropologic' explanation, which regards those similarities as the outgrowth of the unity of human psychological nature and methods.

Dr. J. W. Fewkes gave a detailed description of the figures in the ancient Maya manuscript known as the 'Cortesian Codex.' Other papers presented were: 'Kwapa folk-lore,' Dr. J. Owen Dorsey; 'Korean Children's games,' Stewart Culin; 'Burial and holiday customs and beliefs of the Irish peasantry,' Mrs. Fanny D. Bergen; 'Bibliography of the folk-lore of Peru,' Dr. Geo. A. Dorsey; 'Mental development as illustrated by folk-lore,' Mrs. Helen Douglass; 'The game of goose with examples from England, Holland, Germany and Italy,' Dr. H. Carrington Bolton; 'The Swastika,' Dr. Thomas Wilson; 'Folk-food of New Mexico,' Capt. John G. Bourke, U. S. A.; 'Opportunities of ethnological investigation on the eastern coast of Yucatan,' Marshall H. Saville; 'Two Ojibway tales,' Homer H. Kidder.

The officers elected for the ensuing year were: President, Dr. Washington Matthews; Vice Presidents, Rev. J. Owen Dorsey, Captain John G. Bourke, U. S. A.; Permanent Secretary, William Wells Newell, Cambridge, Mass.; Corresponding Secretary, J. Walter Fewkes, Boston, Mass.; Treasurer, John H. Hinton, New York, N. Y.; Curator, Stewart Culin, Philadelphia, Pa.

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC LITERATURE.

Les oscillations électriques.—H. POINCARÉ, Membre de l'Institut. Paris, George Carré, 1894.

This work contains, briefly stated, a clear mathematical discussion of the general features of the Faraday-Maxwell electromagnetic theory in Hertzian form, and of those special problems bearing upon this theory which are of particular interest to the experimentalist. The mathematical solution of these problems is compared carefully with the results obtained, principally by the experiments of Hertz and of other investiga-

tors who have extended the field of the Hertzian method of investigation. But it should be observed that the experiments of the pre-Hertzian epoch receive their full share of attention, as, for instance, the experiments of Rowland, Röntgen, and others.

The work will undoubtedly exert a very strong influence upon the future developments of the electromagnetic theory, and deserves, therefore, more than ordinary attention. This circumstance should, in the opinion of the reviewer, excuse the length of this review.

General Theory.—Poincaré's discussion divides itself naturally into two parts. In the first part an electromagnetic field with conductors at rest is considered. In the second part the discussion extends to electromagnetic fields with conductors in motion.

The Hertzian method of presentation is adopted in preference to the Maxwellian. Two distinct differences between these two methods should now be pointed out. The first difference is essential, and may be stated briefly as follows:—

Hertz described Maxwell's electromagnetic theory as the theory which is contained in Maxwell's fundamental equations; he stated, however, very clearly that the suppression of all direct actions at a distance is a characteristic feature of this theory. But if it is not a sufficient hypothesis, and if no other hypotheses are clearly stated by Maxwell, then his deduction of the fundamental equations which form the heart and soul of his theory must necessarily lack in clearness and completeness. This is the difficulty which Hertz discovered in Maxwell's systematic development of his own electromagnetic theory, and Hertz obviates this difficulty by starting from the equations themselves as given, proving their correctness by showing that they are in accordance with all our experience.

The second difference is formal only. It may be stated briefly as follows: Maxwell

considered the electrotonic state, discovered by Faraday, as of fundamental importance. The mathematical expression of this state, the vector potential, was considered by him as the fundamental function in his mathematical presentation of Faraday's view of electromagnetic phenomena. Hertz, just as Heaviside did some time before him, considered the vector potential as a rudimentary concept which should be carefully removed from the completed theory just as the scaffolding is removed from a finished building. In place of the vector potential Hertz substituted the electric and the magnetic force as the fundamental quantities. This enabled him to state the fundamental equations of Maxwell in a more symmetrical form than Maxwell did.

It seems that it is principally this second, the formal, difference which decides Poincaré in favor of the Hertzian method. But there is still considerable difference between the presentation of the electromagnetic theory given by Hertz and that which Poincaré gives in this book. For whereas Hertz proceeded from the symmetrical form of Maxwell's fundamental equations as given and by deducing from them and from several clearly defined assumptions the general experimentally established laws of electrical phenomena proved the correctness of these equations, Poincaré deduces them from the following experimentally established facts:

1. The energy of the electromagnetic field consists of two parts, one due to the action of the electric and the other to that of the magnetic forces. They are each homogeneous quadratic functions of the two fundamental quantities, that is of the electric and of the magnetic forces respectively. This experimental relation defines the units of the electric and of the magnetic force and also the physical constants of the medium, that is the specific inductive capacity and the magnetic permeability.

2. Having defined the meaning of mag-

netic and of electric induction and of their fluxes in terms of the corresponding forces, Poincaré states then the fundamental law of electromagnetic induction in a closed conducting circuit as an experimental fact and deduces immediately the first group of the Maxwellian equations. This group is nothing more nor less than a symbolical statement that the law of electromagnetic induction is true for every circuit whether it be conducting or not.

3. Joule's law is stated as an experimental fact. In a homogeneous conductor the heat generated per unit volume and unit time at any point of the conductor is proportional to the square of the electric force at that point; the factor of proportionality is electrical conductivity by definition. Another quantity is then introduced which is defined as the product of the electrical force into the conductivity and the name of conduction current is given to it.

By means of these definitions, the principle of conservation of energy, and the first group of Maxwellian equations, the second group, in the form given by Hertz, is then deduced. This completes the Maxwellian electromagnetic theory for a homogeneous isotropic field in which both the medium and the conductors are at rest.

Poincaré loses no time in commenting upon the physical meaning of these equations, but proceeds rapidly to Poynting's theorem, which introduces one of the most important quantities in the wave-propagation of electromagnetic energy. It is the radiation vector, as Poincaré calls it. A brief remark, however, prepares the reader for the good things that are to come. A comparison of Maxwell's fundamental equations with those of Ampère shows them to be identical except for rapid electric oscillations, when the displacement currents (Poincaré does not mention this name, but only refers to a mathematical symbol) in

the dielectric cease to be negligibly small. For these no provision was made in Ampère's or any other of the older theories. Here then is the starting point of the radical departure of the Faraday-Maxwell view from that of the older theories. Hence the study of Hertzian oscillations takes us into a new region of electrical phenomena, a region entirely unexplored by the older theories, and first brought before our view by the discoveries and surmises of Faraday, by Maxwell's mathematical interpretation of these discoveries and surmises, and by Hertz's confirmation of Faraday and Maxwell.

Hertzian Oscillations.—It is the study of these rapid oscillations which forms the subject of the rest of Poincaré's work under consideration.

Sir William Thomson's theory of the discharge of a Leyden jar forms a fitting introduction to this study. It states clearly the essential elements which should be considered in the study of electric oscillations. They are the period and the decrement. The relation of these to the self-induction, the electrostatic capacity, and the resistance of the circuit are given by this theory and it was verified by many experiments, especially those of Feddersen, who measured the period of these oscillations and also their decrement by a photographic method. But inasmuch as these oscillations were of a comparatively long period, 10^4 per second, they were not apt to furnish a test of the Faraday-Maxwell theory. The waves of the oscillations studied by Feddersen would have been 30 kilometers long and would, therefore, have escaped experimental detection.

Hertz was the first to produce very rapid oscillations, 10^8 per second; but since their period was too short to be measured directly, another method of testing the agreement between theory and experiment had to be devised. This was done by Hertz,

who measured the wave length (about 3 metres in the earliest experiments) of the waves produced by these rapid oscillations by means of the intensity of the spark in the spark-gap of a secondary circuit, the so-called resonator. The period was calculated by the Thomson formula and dividing the wave-length by the period gave the velocity of propagation, which, according to the Faraday-Maxwell theory, should be equal to that of light, and that, too, both in the immediate vicinity of the conductors and in the dielectric. A mere sketch of these experiments is given for the purpose of outlining the plan of the discussion to be carried out in the succeeding chapters of the book. Hertz's method of calculating the period of his oscillators is reproduced more or less faithfully and the various objections against it discussed.

Theory of Hertzian Oscillations.—This discussion paves the way gradually for the general theory of the Hertzian oscillator to be taken up in the next chapter. This theory can be described as the mathematical discussion of the following problem: Given a homogeneous dielectric extending indefinitely. This dielectric is acted upon by a steady electrical force applied at a conductor, the oscillator. It is therefore electrically strained. Describe the process by means of which the dielectric returns to its neutral state when the initial electrical strain is suddenly released.

The discussion must necessarily start from Maxwell's fundamental equations. They are in the form given by Hertz, partial differential equations connecting the components of the electric and of the magnetic forces at any point in the dielectric. Hence, using the language of the mathematician, the solution of the above problem will consist in the integration of Maxwell's differential equations, which, translated into the language of the experimental physicist, means that the solution will consist in find-

ing the resulting electrical wave, that is, its period, its decrement due to radiation and dissipation, and its direction and velocity of propagation. It is evident, therefore, both to the mathematician and to the physicist that the conditions at the boundary surfaces separating the dielectric from the conductor must first be settled. To these Poincaré devotes careful attention. A lucid demonstration is given of the theorems that in the case of rapid oscillations there will be: a. Very slight penetration of the current into the conductor; b. A vanishing of the electric and the magnetic force in the interior of the conductor. c. Electric force normal and magnetic force tangential to the surface of the conductor, etc.

Then follows a beautiful mathematical solution of the general problem mentioned above. It is this: The law of distribution of the conduction current on the oscillator being given the electric and magnetic force, and therefore the state of the wave, at any point in the dielectric and at any moment can be calculated by a simple differentiation of a quantity called the vector potential. This quantity is determined from the current distribution in a manner which is the same as that employed in the calculation of the electrostatic potential from the distribution of the electrical charge, but on the supposition that the force between the various points of the dielectric and the surface of the oscillator is propagated with the velocity of light. The value of this solution rests on the fact that the law of distribution of the conduction current can be closely estimated in some oscillators, as, for instance, in the case of Blondlot's oscillator consisting of a wire bent so as to form a rectangle in one of whose sides a small plate condenser is interposed. A special form of this vector potential applicable to oscillators whose surface is that of revolution is deduced and applied to Lodge's spherical oscillator,

whose oscillations are due to a sudden release of a uniform electrostatic field. The solution of this case is complete. The actual values of both the period and the decrement are expressed in terms of the radius of the sphere. The smallness of the period and the exceedingly rapid rate of decay of the wave are striking.

This theory throws much light upon Hertz's method of calculating the period of an oscillator. Poincaré applies it also to the explanation of the Hertzian method of calculating the decrement due to electrical radiation and the force of Poynting's theorem is exhibited in a masterly manner, although, of course, the calculation for more general cases is not as complete as that for Lodge's oscillator. More experimental guidance is necessary and will not be sought in vain in subsequent chapters.

Phenomena of Electrical Resonance.—Wave Propagation along a Wire.—Having described Hertz's method of calculating the period and the decrement, Poincaré discusses next some of the more important experimental researches dealing with these two principal characteristics of an oscillating system. The earliest method employed in researches of this class is that devised by Hertz. A secondary circuit, the resonator, consisting of a turn of wire with an adjustable spark gap is brought into the inductive action of the oscillator. The length and intensity of the induced spark measures the inductive effect between the two. When the periods of the two are equal the effect is a maximum; they are then in resonance. But experiment reveals the fact that the resonance effect is not as pronounced as in the case of acoustical resonance. Sarasin and de la Rive (Arch. des sciences phys. 23, p. 113; 23, p. 557, Genève, 1890) inferred from this that the oscillator sends forth a complex wave which, if analyzed in the manner of a ray of sunlight, would give a continuous spectrum. Poincaré, guided by a

carefully worked general theory of resonance, ascribes the absence of a strong resonance effect to the large decrement of the oscillator. An appeal is then made to experiments bearing on this point and the subject of stationary waves in long wires is taken up. Such waves are produced in the same way as in the case of sound waves. When a train of electrical waves travels along a wire and the leading wave reaches the end of the wire it is reflected there and by the interference between the direct and the reflected waves stationary waves are formed. Hertz's theory of propagation of these waves is given, showing that their velocity is the same all along the wire and equal to that of light for all wave lengths. If the view of Sarasin and de la Rive be correct then stationary electrical waves should have no pronounced nodes and ventral segments and, therefore, a resonator which, unlike the oscillator, gives a simple wave of definite periodicity will pick out of the stationary waves that component only which is in resonance with it. In other words, every resonator, within large limits, will respond to stationary waves and if moved along a wire which is the seat of such waves its spark will rise and fall in intensity every time the resonator passes by a node or a ventral segment of that component contained in the complex stationary wave with which it is in resonance. It measures, therefore, the wave length corresponding to its own period and not that corresponding to the period of the oscillator. This wave length divided by the calculated period of the vibrator will give, therefore, a wrong velocity of propagation. A mistake of this kind was suspected in Hertz's earliest experiments by which he obtained a different velocity of propagation along a wire from that in the dielectric. Sarazin and de la Rive called this phenomenon, first observed by them, the phenomenon of multiple resonance. It is undoubtedly one of the most

important discoveries in the region of Hertzian oscillations. It was probably ⁽¹⁾ Poincaré (his modesty prevents him from mentioning this fact) who first recognized its full value and detected its true meaning. He devotes a large part of the present work to the discussion of this phenomenon and every serious student will appreciate heartily this very interesting feature of the noble work before us. Briefly stated Poincaré's explanation of multiple resonance is this. Ordinarily the oscillator has a large decrement; that of the resonator is very small, according to the results of Bjerkness' experiments. The train of waves excited in a long wire by the inductive action of an oscillator after each disruptive discharge consists of a big wave followed by a small number of waves of very rapidly decreasing amplitude. Such a train of waves is evidently not capable of forming interference waves after reflection. Their effect upon the resonator is practically the same as that of a single wave, giving the resonator an impulse when passing it on its way toward the end of the long wire and another impulse when it returns after reflection. Hence, if the time interval between these two impulses is a multiple of the period of the resonator the resulting oscillation in the resonator will be stronger than otherwise. If, therefore, the resonator be moved along the long wire its oscillations will vary, passing through a maximum at regular intervals; the distance between these intervals being equal to a wave length corresponding to the period of the resonator. But, obviously, the maxima will be most clearly pronounced when the resonator is in reson-

ance with the oscillator. This is especially true in the case of oscillators possessing a less strongly developed decrement, as for instance, Blondlot's oscillator. This explanation is illustrated by a mathematical discussion of rare elegance and simplicity. Blondlot's experiments (*Jour. de Phys.* 2 serie t. X., p. 549) are then carefully described and the close agreement between them, especially as regards the velocity of propagation along conducting wires, and the above theory pointed out.

Attenuation of Waves.—An important feature connected with wave propagation of Hertzian oscillations along wires was strongly emphasized by these experiments, namely, the diminution of the wave amplitude with the distance passed over. This has long since given Mr. Oliver Heaviside many an anxious thought. Poincaré is evidently not aware of that and he attacks the problem with just as much of his well-known mathematical vigour as if its solution had not been given long ago by Mr. Heaviside. (*Electr. Papers*, Vol. II., p. 39, etc.) A few bold strokes of Poincaré's unerring pen disclose the interesting fact that the attenuation is due, principally, to distributed capacity of the wire, since the decrement, calculated by Poynting's theorem, is shown to be inversely proportional to the diameter of the wire. Experimental evidence bearing upon this point is then reviewed. In these experiments the employment of the resonator had to be discarded and the intensity of the wave at various points of the wire measured directly. Various methods were employed in these experiments. The most important among them are the following :—

(1) It is no more than just that a strong emphasis should be put upon the fact that Bjerkness independently (*Wied. Ann.* 44 p. 74 and p. 92, July, 1891) worked out the same theory and proved it by experiment at about the same time that Poincaré first published his theory (*Arch. des sciences phys.* 25 p. 608, Genève 15 Juin, 1891).

a. Hertz's method (*Wied. Ann.* 42, p. 407, 1891) of measuring the intensity of the wave at any point of a long wire by the mechanical force exerted upon another small conductor suspended in the vicinity of the wire. This method permits a study of the

distribution of the magnetic and the electric force along the wire separately.

b. The method of Bjerkness (Wied. Ann. 44, p. 74) in which two symmetrically situated points of a long loop are connected to the quadrants of a small electrometer and the difference of potential measured.

c. The thermoelectric method [first suggested by Klemencic (Wied. Ann. 42, p. 416)] employed by D. E. Jones (Rep. Brit. Assoc., 1891, p. 561-562). The intensity of the wave at any point of the wire is measured by the thermoelectric effect produced in a thermopile placed in the immediate vicinity of that point.

d. The bolometric method first employed by Rubens and Ritter (Wied. Ann. 40, p. 55, 1890).

e. Perot's micrometric spark gap method (C. R. t. CXIV., p. 165) by which the intensity of the wave at any point is measured by the maximum length of the spark gap when attached to the wire at that point.

The theory of each method is discussed briefly but quite completely, and it is shown very clearly that the results of the experimental investigations cited above are in good agreement with the theory and that they all lead to the conclusion that the oscillations of the oscillator produce simple waves, possessing a rapid rate of decay. This is in accordance with Poincaré's view of multiple resonance.

Bjerkness' experimental method (Wied. Ann. 40, p. 94, 1891) of determining the decrement of a resonator and Poincaré's theory of it are then given and it is shown that this decrement is a hundred times smaller than that of the oscillator.

A brief theoretical discussion of the curves plotted by Perot from the experiments cited above closes this exceedingly interesting and instructive part of the book.

It is pointed out now that the experiments so far discussed do not decide the

superiority of the Maxwellian theory over the older theories because it can be and has been predicted by older theories (Kirchhoff, Abhandl. p. 146) that the velocity of propagation of electromagnetic disturbances along a long straight wire suspended in air is the same as the velocity of light. A review of some of the older experiments in this direction is then given.

Direct Determination of the Velocity of Propagation along Conducting Wires.—The earliest experiments carried out according to methods against which no serious objections could be raised were those of Fizeau and Gounelle (1850) over telegraph lines between Paris and Amiens, a distance of 314 kilometers. The method was similar to that employed by Fizeau in the determination of the velocity of light. The mean velocity was found to be 10^5 kilometers per second for iron wire and 18×10^4 kilometers per second for copper wire. They employed signals of, comparatively speaking, long duration, and Poincaré shows by a reference to well known theoretical relations that in this case there is a strong distortion of the signals, so that a disturbance starting in form of a short wave returns, after passing over the whole line, in form of a more or less steep wave front followed by a long tail. This made the measurements very uncertain and the velocity of propagation necessarily much smaller than it ought to have been. The experiments of Siemens in 1875 avoided this objection, in a measure, by employing the disruptive discharge of a Leyden jar for the purpose of starting an electrical disturbance on lines of varying length, between about 7 and 25 kilometers. The velocity found was in several cases nearly 250,000 kilometers for iron wire. Here again the velocity came out smaller than that of light and for obvious reasons.

The last and in all respects most successful direct determination of the velocity of propagation was that recently carried out by

Blondlot (C. R., 117, p. 543; 1893). The signals were sent over a wire of about one kilometer in length and another of about 1.8 kilometers. In the first case the mean velocity was found equal to 293,000 and in the second to 298,000 kilometers per second which is very close to the velocity of light. Poincaré proceeds now to the discussion of the most severe test of the Maxwellian theory, that is the propagation of electromagnetic waves through dielectrics.

M. I. PUPIN.

COLUMBIA COLLEGE.

(To be Concluded.)

Model Engine Construction.—J. ALEXANDER. —New York and London, Whitaker & Co. 1894. Illustrated by 21 sheets of drawings and 59 engravings in the text. 12mo, pp. viii + 324. Price, \$3.00.

This little book is an excellent treatise on the construction of models of stationary locomotive and marine engines, and contains also instructions for building one form of hot-air engine. It is written by an author evidently familiar with his subject, and the text and illustrations are such as will serve the purpose of both artificer and amateur, desiring to produce model representations of real working engines of standard forms. Bright young mechanics will find here business-like statements of details of drawing, pattern-making, and finishing such models; and, if heedfully complied with, these instructions will result in the production of steam-engines which will actually 'steam,' and which will delight the heart of the mechanic. The drawings are all representative of British practice, and, in some respects, therefore, quite different from familiar practice in the United States; but British practice is 'not so bad,' after all, and many old mechanics, and probably every amateur, will be able to profit greatly by the careful study of this little work.

R. H. T.

NOTES.

PERSONAL.

KARL HANSHOFER, Professor in the University of Munich, and well known through his researches in crystallography and other branches of mineralogy, has died at Munich at the age of fifty-four.

PROF. G. LEWITZKY has been appointed Director of the Observatory in Dorpat, and Dr. L. Sturve succeeds Professor Lewitzky at Charkow.

PROF. F. KOHLRAUSCH, of Strassburg, was proposed as the successor of Hertz at Berlin, but the death of Helmholtz intervening he will now succeed the latter in the Directorship of the Physico-Technical Institute.

GENERAL.

THE discontinuation of the *Index Medicus* is threatened unless sufficient subscriptions are secured before February 1 to defray the costs of publication.

ACCORDING to the *Publishers' Circular* there were 5,300 new books and 1,185 new editions published in Great Britain during 1895, 203 more than during 1894. Of these, 98 new books and 30 new editions are placed under the heading 'Arts, Sciences and Illustrated Works.'

MR. GEORGE F. KUNZ, Special Agent, Division of Mining Statistics and Technology, U. S. Geological Survey, has sent letters asking for information concerning the freshwater pearl fisheries, and concerning precious and ornamental stones of the United States.

PROF. S. P. LANGLEY, Secretary of the Smithsonian Institution, has addressed a letter to the competitors for the Hodgkins Fund Prizes of \$10,000, of \$2,000, and of \$1,000, stating that in view of the very large number of competitors, of the delay which will be necessarily caused by the intended careful examination, and of the further time which may be required to con-

sult a European Advisory Committee, if one be appointed, it is announced that authors are now at liberty to publish these treatises or essays without prejudice to their interest as competitors.

CONGRESSES.

THE sixth International Geographical Congress will be held at London, on July 26, 1895, and continue until August 3. There will be an extensive exhibition in connection with the congress.

NEW AND FORTHCOMING PUBLICATIONS.

W. B. SAUNDERS, Philadelphia, has in preparation *An American Text-book of Physiology*, by Henry P. Bowditch, M. D., John G. Curtis, M. D., Henry H. Donaldson, Ph. D., William H. Howell, M. D., Frederic S. Lee, Ph. D., Warren P. Lombard, M. D., Graham Lusk, Ph. D., Edward T. Reichert, M. D., and Joseph W. Warren, M. D., with William H. Howell, Ph. D., M. D., as Editor.

THE idea of holding International Mathematical Congresses is crystallizing into shape. Prof. Vassilief, of Kazan, has suggested an assembly of mathematicians in 1896, in order to definitely decide the organization of such congresses. The matter was pushed a little further at the Vienna meeting of the Deutsche Mathematiker Vereinigung, in September last, when it was unanimously resolved that the Committee of the Mathematical Union should take part in framing the necessary arrangements; and the Mathematical Section of the French Association for the Advancement of Science have also expressed their support of the scheme. A circular now informs us that the Editors of the *Intermédiaire* will be glad to receive the names of mathematicians who are in favor of international meetings of the kind suggested. M. C. A. Laisant's address is 162 Avenue Victor-Hugo, Paris; and that of M. E. Lemoine, 5 rue Littré.—*Nature*.

FÉLIX ALCAN has just issued the first part (extending as far as *Aliment* only) of an elaborate *Dictionnaire de Physiologie*, edited by M. Charles Richet with the coöperation of the leading French physiologists. The work is expected to contain about 5,000 pages, and to be completed in fifteen parts or five volumes.

GINN & Co. announce for publication in February *Molecules and the Molecular Theory of Matter*, by A. D. Risteen.

APPLETON & Co. announce *The Dawn of Civilization*, by Prof. Maspero, and *The Pygmies*, translated from the French of A. de Quatrefages, by Prof. Frederick Starr.

WHITTAKER & Co. are publishing this year a weekly journal of science combining *The Technical World* and *Science and Art*.

W. ENGELMANN has begun the publication of an *Archiv für Entwicklungsmechanik der Organismen*, edited by Dr. W. Roux.

THE Rose Polytechnic Institute of Terre Haute, Ind., has begun the publication of a series of bulletins of which the first number is *Physical Units*, by Prof. Thomas Gray.

SOCIETIES AND ACADEMIES.

THE ANNUAL MEETING OF THE AMERICAN MATHEMATICAL SOCIETY.

THE annual meeting of the American Mathematical Society was held Friday afternoon, December 28th, at Columbia College, New York. In the absence of the president, Dr. Emory McClintock, and of the vice president, Dr. G. W. Hill, Professor R. S. Woodward, of Columbia College, presided. Among those present were Professor Simon Newcomb, Professor J. M. Van Vleck, Professor Henry Taber, Professor Mansfield Merriman, Professor H. D. Thompson, Professor Mary W. Whitney, Dr. E. L. Stabler, Mr. P. A. Lambert, Mr. R. A. Roberts, Dr. Charlton T. Lewis, Mr. Gustave Legras, Professor J. H. Van Amringe, Professor Thomas S. Fiske, Dr. E. M.

Blake and Mr. G. H. Ling. In the secretary's report, it was stated that the total membership of the Society was 251. The council and officers elected for 1895 were as follows: President, Dr. George W. Hill; Vice President, Professor Hubert A. Newton; Secretary, Professor Thomas S. Fiske; Treasurer, Professor R. S. Woodward; Librarian, Dr. E. L. Stabler; Committee of Publication, Professor Thomas S. Fiske, Professor Alexander Ziwet, Professor Frank Morley; Other Members of the Council, Professor Thomas Craig, Dr. Emory McClintock, Professor Mansfield Merriman, Professor Henry B. Fine, Professor E. Hastings Moore, Professor Ormond Stone, Professor Simon Newcomb, Professor Charlotte Angas Scott, Professor Henry S. White.

The address of the retiring president, Dr. McClintock, was read to the Society by Dr. Charlton T. Lewis. It was entitled *The Past and Future of the Society*. The following papers were also read: *On a Certain Class of Canonical Forms*, by Mr. Ralph A. Roberts; *A New Definition of the Hyperbolic Functions*, by Professor Mellen W. Haskell.

THOMAS S. FISKE, *Secretary*.

COLUMBIA COLLEGE.

IOWA ACADEMY OF SCIENCES.

Ninth annual session, Des Moines, Iowa, December 27 and 28, 1894.

Thursday Morning, December 27.

1. *Inter-Lacial Till near Sioux City*: J. E. Todd and H. Foster Bain.

2. *Pre-Glacial Elevation of Iowa*. 3. *The Central Iowa Section of the Mississippian Series*: H. Foster Bain.

4. *Secular Decay of Granitic Rocks*. 5. *Structure of Paleozoic Echinoids*. 6. *Opinions Concerning the Age of the Sioux Quartzite*. 7. *Illustrations of Glacial Planing in Iowa*: Charles R. Keyes.

8. *Record of the Grinnell Deep Boring*. 9. *The Topaz Crystals of Thomas Mountain, Utah*: Arthur J. Jones.

10. *The Lansing Lead Mines*: A. G. Leonard.

11. *How Old is the Mississippi?* 12. *On the Formation of the Flint Beds of the Burlington Limestones*. 13. *Coincidence of Present and Pre-Glacial Drainage Systems in Extreme Southeastern Iowa*. 14. *Extension of the Illinois Lobe of the Great Ice Sheet into Iowa*. 15. *Glacial Markings in Southeastern Iowa*: F. M. Fultz.

16. *The Maquoketa Shales in Delaware County, Iowa*. 17. *On Some Supposed Devonian Outliers in Delaware County, Iowa*: S. Calvin.

18. *On the Occurrence of Megalomus Canadense in the LeClaire Beds at Port Byron, Ill.*

19. *Geological Section of Y. M. C. A. Artesian Well at Cedar Rapids, Iowa*: William H. Norton.

Thursday Afternoon.

20. *President's Address: Some Recent Work on the Theory of Solutions*: L. W. Andrews.

21. *Report of Committee on State Fauna*: C. C. Nutting.

22. *A New Method of Studying the Magnetic Properties of Iron*. 23. *On the Design of Transformers and Alternating Current Motors*. 24. *Note on a Phenomenon of Diffraction in Sound*: W. S. Franklin.

25. *A Kymograph and its Use*: W. S. Windle.

26. *The Volatility of Mercuric Chloride*: A. C. Page.

27. *Notes on Applying Pollen in the Cross-breeding of Plants*: N. E. Hansen.

Friday Morning, December 28.

28. *Changes that Occur in the Ripening of Indian Corn*: C. F. Curtiss.

29. *Methods of Soil Analysis*: G. E. Patrick.

30. *The Coal Supplies of Polk County, Iowa*: Floyd Davis.

31. *A Study of the Nitrogen Compounds of the Soil*: D. B. Bisbee.

32. *A Chemical Study of Honey*: W. H. Heileman.

33. *Notes from the Chemical Laboratory, Iowa Agricultural College, 1894*: A. A. Bennett.

Friday Afternoon.

34. *Effects of Heat on the Germination of Corn and Corn Smut*: F. C. Stewart.

35. *A General Discussion of the Family Psyllidæ, with Descriptions of New Species found at Ames, Iowa*: C. W. Mally.

36. *New Species of Thripidæ*: Alice M. Beach.

37. *Studies of Migration of Certain Aphididæ*: Herbert Osborn and F. Atwood Serrine.

38. *Description of a Species of Aphid Occurring on Carex*: F. Atwood Serrine.

39. *The Pollination of Cucurbits*—by title: L. H. Pammel and Alice M. Beach.

40. *Notes on the Pollination of Some Flowers*: Alice M. Beach.

41. *On the Migration of Some Weeds*. 42. *Notes on Fungus Diseases of Plants at Ames, Iowa, 1894*—by title. 43. *Notes on the Flora of Western Iowa*—by title: L. H. Pammel.

44. *The Action of Antiseptics and Disinfectants on Some Micro-organisms*: L. H. Pammel and O. H. Pagelsen.

45. *Notes on a Micrococcus which Colors Milk Blue*: L. H. Pammel and Robert Combs.

46. *On the Structure of the Testa of Polygonaceæ*: Emma Serrine.

47. *A Study of the Glands in Hoptree (Ptelea Trifoliata)*: Cassie M. Bigelow.

48. *Graphic Representation of the Properties of the Elements*. 49. *Strata Passed in Sinking a Well at Sidney*: T. Proctor Hall.

50. *Notes on the Minerals of Webster County*: Arthur C. Spencer.

51. *Some Notes on the Reptiles of Southeastern Iowa*. 52. *Bones Found in a Cave in Louisa County*. 53. *Mastodon and Mammoth Remains in Southeastern Iowa*: A. H. Conrad.

54. *Cement Clays in Iowa*. 55. *Conclusions as to the thickness of the Upper Carboniferous in Southwestern Iowa*: E. H. Lonsdale.

56. *A Geographical and Synonymic Catalogue of the Unionidæ of the Mississippi Valley*: by title, R. Ellsworth Call.

Officers for 1895 were elected as follows: President, H. W. NORRIS.

1st Vice President, C. R. KEYES.

2d Vice President, T. P. HALL.

Secretary-Treasurer, HERBERT OSBORN.

Librarian, H. FOSTER BAIN.

Executive Committee, Elective Members: W. H. NORTON, N. E. HANSEN and T. H. McBRIDE.

SCIENTIFIC JOURNALS.

AMERICAN JOURNAL OF SCIENCE, JAN.

Late Glacial or Champlain Subsidence and Re-elevation of the St. Lawrence River Basin: By W. UPHAM.

Automatic Mercury Vacuum Pump: By M. I. PUPIN.

Graphical Thermodynamics: By R. DE SAUSURE.

Application of the Schroeder-Le Chatelier Law of Solubility to Solutions of Salts in Organic Liquids: By C. E. LINEBARGER.

Preliminary Notice of the Plymouth Meteorite: By H. A. WARD.

Scientific Intelligence.

NEW BOOKS.

Elementary Lessons in Electricity and Magnetism. SYLVANUS P. THOMPSON. New York and London, Macmillan & Co. 1895. Pp. xv + 628. \$1.40.

Popular Scientific Lectures. ERNST MACH. Translated by J. McCORMACK. Chicago, The Open Court Publishing Co. 1895. Pp. 313. \$1.00.

Laboratory Exercises in Botany. EDSON S. BASTIN. Philadelphia, W. B. Saunders. 1885. Pp. 540. \$2.50.

The Aeronautical Annual. Edited by JAMES MEANS. Boston, W. B. Clarke & Co. 1895. Pp. 172.

Outlines of Dairy Bacteriology. H. L. RUSSELL. Madison, Wis., Published by the Author. 1894. Pp. vi + 186.